

CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINES BRANCH
OTTAWA

FUELS AND MINING PRACTICE DIVISION
INTERNAL REPORT FMP 63/42-PRE

DEVELOPMENT AND PROGRESS OF THE PETROLEUM
RESERVOIR ENGINEERING SECTION

by

R. P. Charbonnier

February 1963

1. Field

Petroleum reservoir engineering, and the connected fields of oil and gas production engineering and pipeline engineering. Reservoir engineering, which has now attained the status of a science based on principles of mathematics, physics and chemistry, deals with the transfer of fluids (hydrocarbons, water, etc.) to, from, or within natural underground rock reservoir formations. Estimates of reserves and improvement of production and recovery are the main preoccupations of petroleum reservoir engineers.

2. Objectives

The first objective of the Section which was formed in 1959 is to keep informed of all new developments in the fields outlined in paragraph 1, especially with regard to Canadian conditions. Thus the Fuels Division will be able to answer as well as possible the numerous and increasing demands for advice on petroleum engineering subjects, received from other government agencies (various Divisions of the Department of Mines and Technical Surveys, National Energy Board, Department of Trade and Commerce, Department of Northern Affairs and National Resources, Department of External Affairs, CNR, National Research Council, Provincial Governments, etc.) and from the industry and the Public. An example of work related to this objective is the collection of technical abstracts.

The second objective of the Section is to prepare technical research studies (generally long term projects) in the fields mentioned in paragraph 1, on subjects of special interest for the benefit of the Canadian Public, from the viewpoints of conservation of the national resources of Canada, optimum utilization of these resources, best development of the Canadian oil and gas industries and safety of the Public (especially regarding security of supply of energy and rare substances). An example of such a research programme is the study of optimum oil and gas well spacing.

The third objective of the Section is to study petroleum reservoir engineering subjects, which may be somewhat neglected by the petroleum industry in spite of their national interest for Canada. Petroleum companies and University laboratories must concentrate their research programmes on a limited number of subjects for practical reasons, and usually there is a trend for most research workers to study similar problems, generally emphasizing what they think are the most promising topics of research, especially from the viewpoint of company profits or growth. However there are frequently other fields of research, which may even be more important from a national viewpoint, but not particularly promising either from the viewpoint of the possibilities of short term success of

research, or regarding profits or growth of the companies. An example of such a research programme is the study of underground storage of natural gas in southern Ontario and Quebec.

3. Outline of Work

Project No. 20-2-1: Underground Storage of Natural Gas

Since the completion in 1958 of the Trans-Canada gas pipeline from Alberta to Montreal, it is expected that extreme peaks of gas consumption in Winter will cause great difficulties in southern Ontario and Quebec, in the not too distant future. This project is a study of possible solutions to these problems, including the feasibility of artificial underground storage reservoirs of natural gas and of L.N.G. (liquefied natural gas) in aquifer strata or mined excavations. The production of substitute gases is also under consideration.

This type of research has not been very actively pursued by the oil and gas companies in Ontario and Quebec, probably because it is not very promising technically, due to the relatively unfavourable geological conditions. In addition, it is likely to result in considerable investment expenditures for the companies with limited short term returns. The Universities are not very active either, in this field for various reasons, such as limited staff, facilities and funds. However, this problem is of great importance from a national viewpoint, in order to assure the security of gas supply for the Public in southern Ontario and Quebec, and to achieve the best conditions of utilization of the gas pipelines and installations, with the optimum development of Canadian gas resources.

For this project, a close liaison has been established with the Canadian oil and gas industry, and a number of government and research organizations in Canada, the United States and Europe. An extensive literature survey has been undertaken and will be kept up to date. Numerous abstracts of technical papers especially from European publications were prepared, and a selection of our literature survey has been requested by the Canadian and American Gas Associations. The latter Association has incorporated a large number of our references in its AGA special bibliography on gas storage, because of the great interest offered by some of the European papers on aquifer storage, which is not too well known in America, but likely to become more and more attractive in the Eastern United States and Canada. A report entitled "Selected Abstracts on Underground Storage of Gas" has been prepared, for the benefit of engineers specially interested in gas storage in aquifers.

With the cooperation of the Geological Survey of Canada, a report has been published under the title: "Present Status of Underground Storage of Natural Gas in southern Ontario and Quebec". This Information Circular IC 121 was requested by over a hundred petroleum companies, and excerpts were published in OILWEEK of March 13, 1961.

In this project, estimates of the future trends of the requirements for gas storage in Eastern Canada have been based on the experience obtained in the United States under similar circumstances. Various aspects of underground gas storage have been considered, including an example of evaluation of natural gas market requirements in southern Ontario, a survey of the design and operation of partly depleted fields and aquifer reservoirs, and some cost data. It was concluded that the storage facilities now available and those, that can be prepared in the near future in southwestern Ontario seem to be quite adequate for the expected market requirements in that area. However the situation is not as favourable in southeastern Ontario and the St. Lawrence Lowlands, where there are no partly depleted gas fields, and where there are only a few geological structures, which may offer suitable aquifer storage of natural gas. The available data are very limited at present, and much geophysical, drilling and core analysis work is required, to ascertain the possibilities of any of the favourable areas, which have been proposed in Information Circular 121, or to discover new promising locations in the regions suggested therein. In view of the large capital investment and relatively long and careful developments required, it seems very important to give, as early as possible, proper consideration to the preparation of adequate storage capacity and deliverability, for the new and fast growing natural gas industry in southeastern Ontario and southern Quebec.

As the conclusions of this study were not very optimistic, regarding the facility of selecting and preparing artificial storage reservoirs of gas in southeastern Ontario and the St. Lawrence Lowlands, other solutions are now under consideration, such as the storage of natural gas in liquefied form (thereby reducing the required volume over 600 times), the production of substitute gases from propane or refinery light end products, and other techniques, which may be of interest at least on a limited scale.

Our studies for this Project No. 20-2-1 have been published in "Oil in Canada", "Gas Age" and also in "Gas World" in Britain.

A contribution was also made to the annual survey on gas storage projects published in the "Oil and Gas Journal" of May 8, 1961, pp. 83-9.

The possibilities of underground storage in the recently discovered gas field of Pointe du Lac, near Three Rivers, Quebec, have not yet been either confirmed or infirmed by the two dozens of wells now drilled. Only after the field is on full production will it be possible to ascertain its potentialities for storage, probably by deeper drilling, because, although its location is fairly attractive, its depth is too shallow to provide a definite solution to the current problems of gas peak shaving in the Saint Lawrence area.

In the meantime, Information Circular IC 121 has been translated into French, brought up to date, and extended in greater details regarding the situation in Quebec.

Project No. 20-2-2: Secondary Recovery Methods

This is a long term project of wide scope, which is to include the study of specific aspects of the recovery of petroleum by artificial methods, instead of, or in addition to, the primary recovery, obtained by methods using the natural sources of energy existing in the reservoirs. These studies deal with subjects of national interest, or relatively neglected by the industry because of the difficulties involved or the absence of short term possibilities. The various sub-projects are as follows:

Project No. 20-2-2/1: Optimum Well Spacing

Well spacing is a very important factor of petroleum production especially in secondary recovery operations. Present spacing in Canada seems to be much too close in general, and may result in great wastes, as compared with the practices adopted in some other countries outside North America. Traditional and legal causes, as well as individual interests seem to have usually prevailed against technical considerations and national interests. This project is a study of the desirability of changes in well spacing standards now used in Canada.

As the Canadian oil and gas industries approach maturity, it is more and more widely argued that excessive drilling of development wells has often occurred to the detriment of discovery drilling, thus resulting in a large surplus of productive capacity, which must remain unused because of limited markets. At the same time, the rate of growth of petroleum reserves has been relatively low in spite of the considerable expenditures of the petroleum industry. It therefore seems that a change in the distribution of available funds might be desirable, in favour of discovery expenditures instead of the alleged over-development of proved fields.

A literature survey has been undertaken for this very important problem which, although it has been the subject of many papers, is still the source of numerous controversies. This project will be greatly assisted by the liaisons, which have been established with some conservation agencies, with the Interstate Oil Compact Commission I. O. C. C., and with several companies notably active in this field, such as the Humble Oil Company in the U. S. A. A statistical analysis of the available data is likely to be most useful in this case, since laboratory studies have not been sufficiently convincing, for the required comparisons of various long term operating conditions of reservoirs with similar characteristics, developed under different spacing arrangements.

In our meetings, in recent years, with officials of the Alberta Oil and Gas Conservation Board, the desirability of modifying well spacing practices in western Canada towards wider spacing, at least in the early stages of oilfield developments, had been firmly advanced by us. The need for such changes has now been officially recognized by a number of large oil companies and finally by the government of Alberta, which has recently increased the initial spacing for new oilfields to 160 acres. This is an important step in the right direction and similar modifications are desirable in the other Canadian oil provinces. However it seems that early spacing should be even wider and not necessarily fixed by an arbitrary figure like 160 or any other. Instead of having the present symmetrical patterns of equidistant wells, located mainly according to legal rigid regulations, it would be much better from a technical and economical viewpoint to select the well sites and therefore the spacing (which could be constantly changing) on the basis of technical and economical considerations, such as topography, surface developments, geological studies, geophysical data, reservoir engineering characteristics, market requirements, proximity to gathering pipelines, processing plants, and funds available for various alternative investments.

Obviously some of these factors have at present some limited influence on well drilling, but mainly on the date of drilling rather than on the location. Many spacing changes now adopted after long delays, come too late. This project includes the study of some successful well spacing practices outside of the U. S. and Canada.

Project No. 20-2-2/ 2: "In-Situ" Combustion for Heavy Crudes

The "In situ" combustion method of oil production is based on the combustion of a small percentage of the oil with injected air (or oxygen), in order to heat the remaining oil and thereby reduce its viscosity to improve its flowing properties.

The possibilities of this recent method, which has had very few commercial applications yet, are most attractive for heavy crude oils, such as that from the Lloydminster field in Alberta and Saskatchewan.

This project deals mainly with the application of these principles for the exploitation of the Athabasca oil sands, essentially according to the Richfield programme of explosion of a nuclear device just below the oil sands, to provide heat and shock wave energy. Our interest in this case is from the national viewpoint of development of Canadian resources, and in order to be able to advise, as well as possible, the governmental authorities concerned with this project. Consequently, a large number of project reports, from the U.S. Atomic Energy Commission (Plowshare programme), Richfield Oil Company, the U.S. Bureau of Mines, and the Lawrence Nuclear Laboratories of the University of California, have been studied in view of the possible applications of nuclear energy in oil production, in mining, in underground steam production for power, and in underground in-situ chemical treatment of minerals.

Project No. 20-2-2/ 3: Miscible Phase Flooding

This project deals with the possibilities of using new miscible fluids, such as alcohol or carbon dioxide, to form a bank sweeping the oil under the pressure produced by injection of gas or water. There are already many commercial projects successfully using LPG (liquefied petroleum gases such as propane, butane, etc.) as a miscible slug to drive the oil. However other fluids may also be adequate and even preferable, if more efficient or more widely available under satisfactory conditions. At present, this project consists chiefly of the gathering of literature information and observations of the very few experiments and pilot projects now conducted in the U. S. A., in view of their applicability in Canada.

Project No. 20-2-2/ 4: Comparative Review of Secondary Recovery projects in Canada

For some types of reservoir engineering studies, it is very useful to collect numerous data on the characteristics of various secondary recovery projects, and to compare similar characteristics, especially with the aid of statistical methods such as correlations. Usually such studies are rather speculative, and more useful for the industry, or even the nation as a whole, than for any individual company.

As a result, in the few cases, when such studies have been undertaken, it was by a government agency, and with the help of professional or trade organizations. In Canada, even Alberta still has a relatively small number of secondary recovery projects and limited production, but for Canada as a nation there would now be considerable advantages in preparing — periodically — some detailed reviews of the numerous important characteristics of all secondary recovery projects in Canada, without waiting for each province to have a sufficiently large and mature petroleum industry to undertake such a survey on its own. A preliminary limited collection of such data obtained in 1960 will be enlarged and arranged in a much more convenient tabulation, suitable for comparative analyses of various important characteristics of Canadian secondary recovery projects.

Project No. 20-2-3: Developments in Petroleum Production Methods

This is another long term project, including studies of some of the new developments in production engineering, which may be of special interest in Canada because of particular local conditions. The various sub-projects are as follows:

Project No. 20-2-3/1: Turbo-drilling and electro-drilling

This project is a study of the possibilities of application of turbo-drilling and electro-drilling in the Northwest Territories, as these methods may have great advantages (because of the faster drilling rates, which they may yield with lighter equipment) in areas, where climate conditions make it imperative to drill as many holes as possible, while the ground is frozen, and where transportation is very difficult and expensive.

In the conventional rotary drilling, the drilling bit is rotated from the surface through the long column of tubing with very large losses of energy in deep holes (by friction on the walls of the hole). Strong and therefore heavy tubing is thus required. In turbo-drilling, the lighter tubing column is practically stationary, and the drilling bit is rotated (at much higher speeds) by a hydraulic turbine located just above the bit. In electro-drilling, the hydraulic turbine is replaced by an electric motor.

Efficiencies can therefore be much greater in turbo-drilling and electro-drilling, with lighter tubing. For many years, turbo-drilling has been the main method of well drilling in the USSR, which also seems to pioneer in the development of electro-drilling. However turbo-drilling in the USSR was especially successful because of the shortage of good quality steels, required for tubings in good rotary drilling. This situation did not apply in most of the Free World, where perfected rotary drilling has been advantageously compared with relatively elementary

turbo-drilling. Great modifications of the drilling bits and auxiliary equipment (pumps, etc.) were required to give a fair chance to turbo-drilling. This work is now in process, mainly in France, where excellent results have recently been obtained using new diamond bits and various other improvements.

New developments especially in France and the USSR will be closely watched for this project (which may require field trips to these countries) in view of the great possibilities in the Northwest Territories. It may be that the U.S. Companies have not been very active in this field, because the main advantages of turbo- and electro-drilling would be obtained in extremely cold or desertic areas, and, with their surplus of rotary drilling equipment in the U.S. in recent years high drilling speed is not as important as in countries where drilling equipment is limited.

Project No. 20-2-3/2: Well Completion Developments

This project deals with the adaptation to Canadian conditions of new methods of well completions. Up to now it has been mainly concentrated on the development of the Permeator technique and equipment invented by S. M. Zandmer of National Oil Field Service Ltd., Calgary, Alta.

This technique uses telescopic pipes, preinstalled on the casing for the perforation of the well, with a casing cement which is expanding on setting, so that it is claimed that the casing cement remains firmly and continuously bonded to the casing and to the hole walls, and that the cement will not be cracked or damaged, as with the usual perforators (bullets or shaped charges). In addition to the technical possibilities of this method, our main concern in this case is that it is likely that the cements used by Zandmer are of a type formerly developed by M. F. Goudge of the Mines Branch, and communicated by him to S. M. Zandmer a few years ago. This cement is covered by Canadian patent application 667,184 Goudge, and, as the Department of Mines and Technical Surveys is directly interested in this patent, the situation is under permanent observation, in cooperation with the Industrial Minerals Division and the Patents Office of the Department.

The technique now seems to be proven, and is widely applied by Home Oil Limited in the Swan Hills field of Alberta (over 30 wells thus treated), also in California and the Sahara. However it seems that in some cases at least, the cements, indicated as used for the casing, have been the standard Litepos and Latex cements. In view of the confused situation, our technical advices have been requested to assess some aspects of the patent position.

Project No. 20-2-4: Transportation and Storage of Petroleum Products

This is a long term field of studies, dealing with new developments in methods of the pipeline industry and other systems of transportation of oil, gas, and other petroleum products under the particular Canadian conditions. Storage of these products at various points along the supply lines is also under study, and Project No. 20-2-1 "Underground Storage of Natural Gas" is an outgrowth of this more general project.

Transportation and storage of oil in the Northwest Territories has been the main subject under consideration, because of the serious difficulties due to the long periods of extreme cold, and the lack of experience and research efforts along these lines by the industry. In addition to operations research to achieve optimum shipments programmes during an open navigation season, prolonged by improved ice-cutters, etc., new methods of transportation, such as nuclear submarines pulling submarine tankers, are under consideration. New developments on similar problems in Alaska and the Northern USSR will be studied. Research on transportation of crudes of usual viscosity in extremely cold climates is likely to be related to the problems of transportation of the very heavy oils of the Athabasca sands or the Lloydminster fields in the milder Northern Alberta climate.

Extremely low ambient temperatures would facilitate the liquefaction of natural gas in the Canadian Arctic Islands for its transportation to Northwestern Europe, but the overall economics of such a scheme are doubtful at present although conditions are quickly changing in Europe, and similar developments in France for the transportation of LNG from the Sahara will be closely observed.

Other topics under consideration include the pipelining of sulphur, or sulphur products such as H_2S , or sour gases containing them, pipelining of coal and other products in oil or water on very long distances.

Project No. 20-2-4/1: Pipeline Technology

The transportation of solids in pipelines is the main subject under consideration in this project. A "Working Party on Movement of Solids" has been created partly in cooperation with the Dominion Coal Board, which is of course mainly interested in the transportation of coal, whereas the transportation of any solids may be of interest to us. This "Working Party" includes J.H. Walsh, A. Brown, and R.P. Charbonnier. With J.C. Botham, J.H. Walsh earlier contributed studies on the economics of coal and ore transportation in western Canada, and held discussions with the U.S. Bureau of Mines and railroad officials in Washington, D.C., and in Virginia. The second member of the Party is A. Brown, who visited solids pipeline installations of

the Consolidation Coal Company in Ohio, and of the American Gilsonite Company in Utah. He also attended the session on hydraulic transportation of solids at the American Mining Congress meeting of May 6-9, 1962. These visits were reported in IR FMP 62/113-MIN, entitled "Working Party on Movement of Solids, Report No. 1, "Long distance pipelining of slurries in the U.S.", by A. Brown (May 1962).

In connection with this Project, E. R. Mitchell has interviewed possible users of coal slurries in Canada.

An important bibliography on the subject is kept up to date, and discussions have been held with CNR and Lasalle Hydraulic Laboratories officials. On May 17, 1962, R. P. Charbonnier participated in the "Pipeline Development Discussion", organized in Edmonton, Alta., by the Research Council of Alberta (RCA) with a view to discussing the feasibility of scaled-up research work (beyond the laboratory level) on the subject of transportation of solids by pipeline, further to the laboratory work completed in recent years in the Research Council pilot plant. The RCA proposed the establishment of a large scale research station, under its leadership, but mainly financed by the industry. This meeting was reported in detail in IR FMP 62/76-PRE entitled "Working Party on Movement of Solids, Report No. 2, Pipeline development discussion, Edmonton, May 17, 1962" by R. P. Charbonnier (May 1962). An outcome of the meeting was the formation of a Steering Committee to study the RCA proposals and recommend a course of action. A Solids Pipeline Sub-Committee was later created, which requested contributions to a Solids Pipeline Research Trust Fund of the RCA. As of September 12th, seventeen companies had contributed \$1,000 each to a study carried out by Dr. Boston on the pipelining of solids. However apparently neither the Dominion Coal Board nor the National Energy Board gave financial support at this stage, and the Mines Branch did not seem to be in a position to contribute significantly either.

In the meantime, during a field trip by R. P. Charbonnier in Europe in Summer 1962, inquiries were made to assess the importance of the facilities and activities of the few organizations engaged in research on the transportation of solids by pipelines. It appeared that, outside of the U.S. and Canada, most of this type of research has been conducted in Great Britain, France and communist countries (mainly the USSR). During visits at the Chemical and Petroleum Engineering Exhibition of the Third Congress of the European Federation of Chemical Engineering, numerous inquiries were made from various companies and organizations likely to have an interest in the transportation of solids by pipeline. An abundant documentation was collected and useful contacts were established. It was confirmed that most of this specialized research in Britain had been carried out by the National Coal Board (NCB) and the British Hydromechanics Research Association (BHRA) and more recently by the Central Electricity

Generating Board (CEGB). At present the CEGB is practically the only active organization in this field, but a lot of experience was acquired by the NCB until 1960, when it suspended this type of research studies, apparently for economical rather than technical reasons. Visits were made to the NCB and to the CEGB solids pipeline research station in Brighton-Hove, and extensive information was obtained, as reported in detail in IR FMP 62/166-PRE, entitled "Working Party on Movement of Solids, Report No. 4, Research on the transportation of solids by pipeline in Britain" by R. P. Charbonnier (September 1962).

Later, in W. Germany, it was found that most of the engineering research for the new long distance coal slurry pipeline to be built in the Ruhr, is obtained from the Consolidation Coal Co., in the U.S., acting as Engineering Consultants, on the strength of its experience in the building and operation of the 100 mile coal pipeline Cadiz-Cleveland (Ohio).

Finally, in Grenoble, France, the solids pipeline research establishment of Neyrpic-Sogreah was visited. Neyrpic is one of the largest hydraulic equipment manufacturers in the World and its testing facilities for solids pipelining are very extensive. Of the 44 projects that have been studied up to date, about half have been adopted and they included the full scale construction of the solids pipelines as proposed. The pipelines already built are of all kinds, small and large in diameter, short and long distance; they handle a wide variety of materials from coal, ores and tailings to chemical products and even capsules similar to the types proposed by the Research Council of Alberta. Although the Consolidation Coal Company and the American Gilsonite Company in the US are likely to have the advantage of experience in building and operating extra long pipelines (about 70 and 100 miles), their experience is limited to one material and one set of conditions. On the other hand, Neyrpic-Sogreah seems to have the widest experience in the variety of materials and conditions tested, backed by a very powerful hydraulic manufacturing organization. Incidentally it may be noted that the equations, proposed by Durand and Condolios of Neyrpic as early as 1952, have been confirmed and widely adopted by the research workers in the other centres. As to the costs of the services of Neyrpic-Sogreah, it appeared that they could be available on a very reasonable basis, as indicated in Report No. 6 of the Working Party on Movement of Solids, entitled "Research on the transportation of solids by pipeline in France" by R. P. Charbonnier.

Regarding the new method of transportation of solids called "Mobile Pipelines", a detailed documentation was obtained in France, and discussions were held by R. P. Charbonnier with the SECCAM research officials on the stage of development of the models and large scale testing facilities at Aubigny, near Paris. This method seems to be quite promising under certain conditions as an attractive alternative to railroads, truck haulage and solids pipelines. It should be carefully considered for the short to medium distance transportation of several million tons per year of small size solids, specially in rough, undeveloped terrain. A report has been prepared concerning this new technique under the title "Working Party on Movement of Solids, Report No. 7, Research on the transportation of solids by mobile pipeline" by R. P. Charbonnier. A new project is now under consideration for the purpose of improving this new technique by using a more uniformly applied drive, a much lighter and cheaper structure, and a more efficient suspension system.

Project No. 20-2-5: Documentation

The purpose of this project is to try to have at all times the best system of information on new developments in petroleum technology and research projects. It has been concentrated on abstracts of publications and liaison with government agencies, the industry and the public.

Abstracts

Information regarding new developments is essential. Publications on oil and gas technology are more and more abundant (recent yearly rate of increase: 12% in the U. S. A.), and literature surveys and abstract preparation are increasingly time-consuming. Like for most of the oil and gas companies and research organizations, except maybe the largest, it is best for us to use a service of classified card abstracts, prepared on a large scale by abstracting professionals, to reduce the high costs of such essential work. Outside of the USSR, there are apparently only two sources of adequate petroleum card abstracts: ~~the American Petroleum Institute~~

the American Petroleum Institute, which is rather costly (\$1,500/year/set of abstracts), and the French Petroleum Institute, which is subsidized and offers a similar service at a much lower cost (about \$116/year/set). The FPI abstract cards are available (in French only) separately in each of eight different general sections. Since 1960, the collection of FPI abstract cards on "Petroleum Exploration and Production" has been regularly received, and its usefulness has quickly increased with its volume, thanks to the excellent indexing system.

For 1962, our subscription has been extended to cover all aspects of the petroleum industry, and we shall now receive the complete set of FPI abstract cards, which will be essential in answering the numerous inquiries, received by the various petroleum sections of the Division of Fuels and Mining Practice, from other government agencies, the industry, and the Public.

This service would be unique in Canada and the USA, and, after the abstract cards collection has been adequately enlarged, it should be very valuable for many users, since only the larger oil companies subscribe to the API service, and then they are engaged by contract not to give the benefit of the API cards to anyone else. The FPI cards have no such restriction, but they are in French, which raises difficulties for the Canadian petroleum industry that is practically exclusively English speaking.

Liaison

It is essential for our work that good liaison be maintained regarding new developments with all parties interested and active in our field. Therefore numerous contacts have been established with various Provincial oil and gas conservation agencies, other organizations of the Federal government such as the National Energy Board, the Canadian Petroleum Association, the Canadian Gas Association, many oil, gas, pipeline, service, and consulting companies, university research laboratories and councils, the U.S. Bureau of Mines, the Interstate Oil Compact Commission, the French Petroleum Institute, the "Centro Europeo Permanente di Informazioni e Documentazione sulla Utilizzazione dei Gas Naturali ed altri Idrocarburi Gassosi", the Coal and Gas Section of the Economic Commission for Europe of the United Nations, and many other Foreign technical organizations of great interest for our documentation.

Estimates of Canadian reserves of oil and gas have been prepared for the 1962 World Power Conference Statistics. Many technical hearings of the Alberta Oil and Gas Conservation Board and of the NEB have been attended, as they are good sources of data for our projects.

Many valuable contacts were established or renewed during field trips in Canada, the USA and France, and at a number of technical conferences of professional or technical societies to which the Section Head belongs, such as the Canadian Institute of Mining, the A. I. M. E. Society of Petroleum Engineers, the World Petroleum Congress, the French Association of Petroleum Technologists, and the French Gas Technical Congress.

Many other technical conferences were attended, such as a seminar on Schlumberger geophysical techniques for oil wells, a conference of the Canadian Operational Research Society (in view of possible applications in petroleum technology), a USBM Research Symposium on Nuclear Applications in the Mining and Petroleum Industries, and the Fourth Congress and Exhibition of the Federation of European Petroleum Equipment Manufacturers. In professional activities, R. P. Charbonnier has been appointed as chairman of the Division of Mining and Metallurgical Engineering, Committee on Technical Operations, of the Engineering Institute of Canada. He also was recently offered a directorship on the Executive of the Petroleum and Natural Gas Division of the Canadian Institute of Mining and Metallurgy."

In connection with this liaison work, numerous services of a consulting nature have been rendered to other government Departments, Industry, and the Public, mainly on new developments in petroleum reservoir engineering and related fields, especially in connection with our research projects. For instance, the feasibility of storage of natural gas, in a gaseous or liquefied form in the Eustis mine near Montreal, has been discussed with Mr. F. R. Burton, President of Alminex Ltd. and Meneta Porcupine Mines Ltd.

In connection with this Documentation project, a number of literature surveys, technical translations, and technical editing of papers, have been performed for other Sections of the Department of Mines and Technical Surveys.

4. Selected Reports and Publications

TM 116/59-SP "Underground Storage of Natural Gas" by R. P. Charbonnier.

TM 114/59-SP "Field Trip in South Western Ontario re: Underground Storage of Natural Gas" by R. P. Charbonnier.

IC 121 (1960) "Present Status of Underground Storage of Natural Gas in southern Ontario and Quebec" by R. P. Charbonnier.

IR FMP-60/138-PRE- "Possibilities of Utilization of Surplus Liquefied Petroleum Gas in Railway Locomotive Engines in Canada" by R. P. Charbonnier.

IR FMP 60/149-PRE "Some Recent Developments in Fuel Technology in France" by R. P. Charbonnier.

IR FMP 60/163-PRE "Report on the Fourth National Petroleum Congress, June 1960" by R. P. Charbonnier.

IR FMP 60/167-PRE "Report on the Gas Technical Congress, June 1960" by R. P. Charbonnier.

IR FMP 60/193-PRE "Comments on the U. S. Atomic Energy Commission Project GNOME" by R. P. Charbonnier.

IR FMP 60/206-PRE "Selected Abstracts on Underground Storage of Gas" by R. P. Charbonnier.

Gas Age, 127, No. 9, April 27, 1961, p. 39: "Planning Underground Storage in Canada" by R. P. Charbonnier.

Gas World, 29th April, 1961, p. 601: "Underground Storage of Natural Gas" by R. P. Charbonnier.

IR FMP 61/90-PRE "Comments on the Conference of the Canadian Operational Research Society, May 1961" by R. P. Charbonnier.

Oil in Canada, July 20, 1961, p. 36: "Status of Underground Storage of Gas in southern Ontario and Quebec" by R. P. Charbonnier.

IR FMP 62/6-PRE "Reservoir Engineering Research in Alberta" by R. P. Charbonnier.

IR FMP 62/52-PRE "Some Promising Nuclear Applications in Petroleum and Mining Engineering" by R. P. Charbonnier.

IR FMP 62/76-PRE "Working Party on Movement of Solids, Report No. 2, Pipeline Development Discussion, Edmonton, May 17, 1962" by R. P. Charbonnier.

IR FMP 62/82-PRE "A New Type of Mineral Classification Equipment" by R. P. Charbonnier.

IR FMP 62/166-PRE "Research on the Transportation of Solids by Pipelines in Britain" by R. P. Charbonnier.

IR FMP 62/179-PRE "Research on the Transportation of Solids by Pipelines in France" by R. P. Charbonnier.

**IR FMP 63/ 6-PRE "Stockage Souterrain du Gaz Naturel dans le
Sud de l'Ontario et du Quebec" by R. P. Charbonnier.**

**IR FMP 63/ 20-PRE "Research on the Transportation of Solids by
Mobile Pipeline" by R. P. Charbonnier.**

RPC/ph